

# MEEC

# ELECTRONICS FOR MICRO-SYSTEMS

Individual Assignment Problems Solving Analysis [EN]

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## 1 Problem 1

#### 1.1 Voltage Gain

Considering an ideal OPAMP working on the linear region, the following assumptions were made.

- $Z_{in} = +\infty$
- $Z_{out} = 0$
- $A_d = +\infty$
- $V_{+} = V_{-}$

In order to obtain the value of  $V_{out}(V_{in})$ , it is necessary to get the circuit equations.

$$\begin{cases} i_{t} = \frac{V_{-}}{R_{1}} \\ V_{x} = V_{-} + R_{2} \cdot i_{t} \\ V_{out} = V_{x} + R_{3} \cdot i_{3} \\ i_{3} = i_{t} + i_{4} = i_{t} + \frac{V_{x}}{R_{4}} \end{cases}$$

$$(1)$$

Where  $i_t$  is the current passing through  $R_1$  and  $R_2$ ,  $V_x$  is voltage between  $R_3$  terminals. This results in the following equation.

$$V_{out} = \frac{R_1 R_4 + R_2 R_4 + R_3 (R_1 + R_2 + R_4)}{R_1 R_4} \cdot V_i$$
 (2)

## 1.2 Input Current Bias

In order to calculate the impact of the current bias, a current supply is placed in parallel on the input terminals of the OPAMP. As shown in the figure

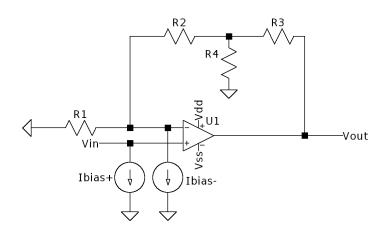


Figure 1: Circuit with input bias current



Using superposition, to evaluate the current effect on the output, the following system of equations is obtained.

$$\begin{cases} V_{-} = V_{+} = 0 \\ I_{R_{1}} = 0 \\ \frac{V_{x}}{R_{4}} + \frac{V_{x} - V_{out}}{/} R_{3} + I_{bias} - V_{out} = I_{bias} - \frac{V_{x} - V_{out}}{R_{3}} \end{cases}$$

$$(3)$$

## 2 Problem 5

#### 2.1 Considerations

- $T1 = 42 \ C^{\circ} = 315.15 \ K$
- $T2 = 42.5 \ C^{\circ} = 315.65 \ K$

#### 2.2 NTC

Using the beta model:

$$R = R_0 e^{\beta \left(\frac{1}{T} - \frac{1}{T_0}\right)} \tag{4}$$

From the datasheet:

- $\beta = 3988$
- $R(25^\circ) = 5k\Omega$

Therefore:

$$R = 5K \cdot e^{3988 \cdot \left(\frac{1}{T} - \frac{1}{298.15}\right)} \tag{5}$$

Hence: R(T1) = R(T2) =





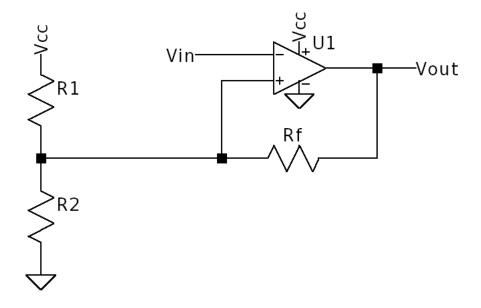


Figure 2: Comparator with hysteresis circuit [1]

For circuit dimensioning the following equations were used <sup>[2]</sup>.

$$\begin{cases} \frac{R_f}{R_1} = \frac{V_L}{V_H - V_L} \\ \frac{R_2}{R_1} = \frac{V_L}{V_{CC} - V_H} \end{cases}$$
 (6)

But since this circuit is inverting.





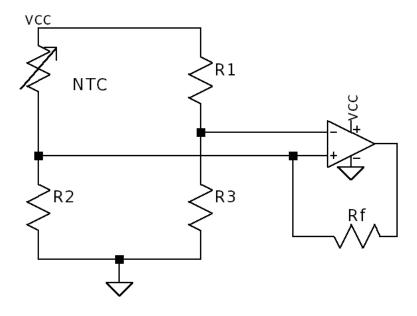


Figure 3: NTC with non-inverting comparator

In this circuit  $V_{in} = V_{CC} \cdot \frac{R_3}{R_3 + R_1}$ ,  $R_1 = R_{NTC}$ .





## References

- [1] TDK, "Ntc thermistors for temperature measuremen," https://product.tdk. com/system/files/dam/doc/product/sensor/ntc/ntc\_element/data\_sheet/50/db/ntc/ntc\_mini\_sensors\_s861.pdf, 2018.
- [2] A. Kay and T. Claycomb, "Comparator with hysteresis reference design," Texas Instruments, Technical Note TIDU020A, June 2014, revised Edition. [Online]. Available: https://www.ti.com/lit/ug/tidu020a/tidu020a.pdf